Memo: Migration Equation proposal for WRCS Sacramento
Date: 10 Nov 2016
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The following migration equation is being considered for WRCS Chinook:

$$V_{Fish} = \beta_0 + \beta_1 \bar{V}\left[\frac{1}{1+e^{-\alpha_1(Q-Q_{crit})-\alpha_2(D-D_{crit})}}\right] + \varepsilon$$

$V_{Fish}$ = mean migration rate on day $D$
$\beta_0$ = parameter that determines the flow-independent migration rate.
$\beta_1$ = parameter relates fish velocity to river velocity. For freshet-movements (non-swimming), this parameter is probably ~1.0.
$\alpha_1$ = sensitivity to the day-to-day flow-effect changes
$\alpha_2$ = sensitivity to the long-term day-effect changes
This will be smaller than $\alpha_1$ and will reflect both the units (days vs. KCFS), and also the sensitivity of fish to time. Ultimately they will move downstream, even without an episodic flow trigger.
Q = flow volume on day $D$
D = day-of-year
$Q_{crit}$ = flow level above which the fish move with the velocity of the water.
In the Sacramento, a lot of the flow is unregulated, so freshets can be significant. Winter flow events exceed baseflows by factors of 2 – 5 or more. 400 $m^3s^{-1}$ = 14 KCFS may be a useful starting value.
$D_{crit}$ = day of year after which the fish move with the velocity of the river
This is a surrogate for biotic and abiotic triggers that become more likely as time goes on: growth, size, age, smoltification, day length, etc.
$\bar{V}$ = mean water velocity in the reach computed with $\bar{V}_D = p_0 \cdot Q^{p_1}$ .
Flow-velocity relationships are well established for the Sacramento River.

In the early season, WRCS fish are known to move quite unremarkably, unless there is a large freshet. This model has the property that late season and/or high flow can trigger rapid migration. Additionally, since the two exponential terms can have opposite signs there is the potential that they mitigate the effect of the other. Thus, in early season, flows may need to be quite a bit higher than the critical value in order to trigger fast migration. Correspondingly, late in the season, even if flows are well below the critical value, fast migration will be triggered.

To examine this model, with full functional control see:

https://cbr.washington.edu/shiny/MIGR_DISTRIB/ .